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(54) SHREDDER CRUSHER MATERIAL REDUCER

(71) We, PENNSYLVANIA CRUSHER CORPORATION, a corporation organised and existing under the laws of Delaware, of Broomall, Pennsylvania 19008, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a material reduction apparatus. In particular the invention relates to a material reducer and separator apparatus which crushes and/or shreds material and throws the crushed and/or shredded material along a confined main path where it can be sorted into light and heavier material.

The reduction and disposal of trash material is a tremendous problem. Every day untold quantities of glass bottles, metal cans, plastic containers, cardboard boxes, aerosol cans, plastic bags, plastic film, paper bags, newspapers, magazines, etc. are put out as trash for collection together with or in addition to the garbage. To collect and dispose of this trash and garbage is a problem of increasing importance to the municipality and to the nation.

Material reduction machines heretofore used to treat these materials have historically imparted a great deal of energy to the materials which are to be reduced. However, in certain prior machines, the energy imparted to the material has not been completely utilized in reducing the material. A substantial portion of the energy has been dissipated in passing the material through size-control grates. Moreover, in prior grate-equipped machines, particles which have not been reduced to sufficient size to pass through the grates generally remain in the reduction area of the machine until the desired smaller size

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has been reached. As a consequence, most of these reduction units have a high degree of material accumulation, and such material is worked on many times before it leaves the machine, in many instances creating excessive fines which clog the apparatus and produce excessive dusting conditions detrimental to the machine and to the operator. The prolonged presence of such large particles in the machine also tends to inhibit the smaller particles, which have already been reduced to sufficient size, from leaving the machine. The aspects described hereinabove have caused prior art material reduction machines to require higher horse power than has been necessary for reducing the material to a given size. Moreover, the aspects above referred to have tended to decrease the through-put capacity of the material reduction machine. In certain other prior machines which both reduce and classify materials, energy has been dissipated by impinging the material against impact or stopping surfaces after discharge from the reducing zone and prior to classification. Certain other machines which may be capable of classifying with low wastage of energy are unsuitable for crushing or shredding and classifying garbage and the like.

A principal object of the present invention is to provide an apparatus for crushing and/or shredding materials including garbage in which the energy imparted to the materials may be more completely utilized in reducing the size of, and in classifying, the material.

Another object is to provide a reduction machine in which the bulk of the material may be passed only once through the area in which reduction takes place.

Another object is to provide a reduction machine in which the bulk of the material which enters the reduction area is quickly removed therefrom with a mini-

mum of further work being performed on it.

Another object is to provide a reduction machine which can have a through-put capacity substantially larger than prior art machines having the same horse power requirement.

The foregoing, as well as other objects and advantages of the invention, are accomplished by certain improvements which we have made upon rotary hammer crushers of the type which have heretofore been used for the reduction of coal, stone and the like.

According to the invention there is provided a material reduction apparatus comprising a rotor housing, a material inlet into the housing, rotatable impacting means mounted in the housing for subjecting the material to blows for reducing and propelling away from the impacting means a stream of solid material including lighter and heavier pieces, a reduced material outlet extending from the impacting means which outlet comprises a first path having at least one path diverging therefrom, and means for providing a flow of air at least in the outlet path to direct the lighter material along said at least one diverging path thereby diverting at least a portion of the lighter pieces from the first path.

As is illustrated by the drawings and description of preferred embodiments set forth hereinafter, specific embodiments of the apparatus according to the present invention include hammers or other rotatable impact means in a housing. On rotation, their peripheries define one or more circle(s), known as hammer impactor circle(s). They are mounted adjacent stator means, i.e. a member or members positioned sufficiently close to the impactor circle(s) for shredding feed material by the combined action of the impactors and stator means on the feed material. The stator means may take various forms, such as a curved plate, including such plates having regular or irregular, wavy or saw-tooth or discontinuous portions, but preferably includes projections or teeth which extend upwardly between laterally spaced impact means. The stator and impactor means discharge a stream of solid material, including lighter and heavier pieces. An output chute or other means which similarly define a first confined path leading away from the impacting means causes the stream of solids to continue, for a time, in flight in the direction in which it is impelled by the blows of the hammers or other impacting means. The stream of material continues in motion in the direction in which it is impelled by the blows of the hammers at least until it passes be-

yond light particle diverting means, such as a branch conduit. More specifically, there is a means defining a second path diverging from the first path for diverting at least a portion of the lighter pieces from the first path. By keeping the heavier pieces in the stream moving in the same general direction imparted to them by the rotor, e.g. causing them to continuously increase their straight-line distance from the rotor at least until they have passed the second path or branch conduit, encourages the heavy pieces to fly by the branch conduit under the influence of such energy. This insures that few of the heavier pieces will gain entry to the light piece diversion path, even if air is used to help sweep the lighter particles out of the stream and into the diversion path.

The impacting means may be axially spaced hammers, with or without multiple prong tips. Projections may be provided if desired which extend into the hammer circle in straight or staggered lines, and these may be adjustable for partial or complete withdrawal from the hammer circle. Means may be provided in the apparatus for wetting the material under treatment. A flow of air may be generated by any means, including the rotatable impacting means. This flow of air can be provided at least in the first confined path, if not in the rotor housing, and may be directed into the second path with the aforesaid lighter pieces, thereby assisting in the separation of the lighter pieces from said stream. The aforesaid second path may connect with a receptacle fitted with adjustable air flow control means such as a damper. A plurality of the machines described in the preceding paragraph may also be arranged in a series wherein a discharge of one machine in the series communicates with a means for introduction of material of another machine in the series.

FIG. 1 is a simplified side view, largely in section, of a shredder/crusher-classifier apparatus according to the invention;

FIG. 2 is a view, in section, looking down along the line 2-2 of Fig. 1;

FIG. 3 is a view, in section, looking along the line 3-3 of Fig. 2;

FIG. 4 is a view, largely in section, illustrating one way in which the projections may be moved into and out of the path of the material to be crushed and/or shredded;

FIG. 5 is a view, in section, illustrating the use of water to lubricate the material as it passes through the rotary hammer position;

FIGS. 6 and 7 illustrate different forms of hammers;

FIG. 8 is a fragmentary illustration of

a modified shredder/crusher-classifier apparatus;

FIGS. 9 through 12 are fragmentary diagrammatic illustrations illustrating different positions which may be occupied by the input and discharge conduits relative to the hammer rotor housing;

FIG. 13 is a view, partly in section, illustrating an alternative mechanism for adjusting the positions of the projections relative to the hammer circle;

FIGS. 14 and 15 are diagrammatic representations illustrating tandem connections of two or more shredder/crusher-classifier apparatus;

FIG. 16 is a sectional view of a shredder/crusher-classifier apparatus having means for recycling of oversize pieces;

FIGS. 17 and 18 are fragmentary diagrammatic illustrations of shredder/crusher-classifier apparatus having varied air flow paths.

Referring to Figs. 1 and 2, the shredder crusher apparatus comprises a rotor housing 10 supported on a base 9. A rotor shaft 11 has keyed thereto a plurality of rotor discs 12, four in the drawings, as seen in Fig. 2. Extending through the four rotor discs 12, at positions spaced 120° apart, are three hammer shafts 15, 16 and 17. Each of the hammer shafts carries a plurality of swing hammers 14, three sets being shown. The swing hammers are positioned between the rotor discs 12 as seen in Fig. 2. Leading down to the hammer circle is an inclined input or feed chute 19. Extending forwardly from the hammer circle, and inclined upwardly therefrom is a discharge chute 30.

In Fig. 1, the floor 13 of the rotor housing 10 is illustrated as being provided with three rows of upward projections 21, 22 and 23. Each of the three rows is illustrated as having four projections in transverse staggered relation, as seen best in Fig. 2. Each of the projections 21, 22 and 23 lies in the vertical plane of one of the rotor discs 12, as also clearly seen in Fig. 2. Thus, the projections lie to either side of the path of the swinging hammers 14. The projections may project at an inclined angle relative to the base so as to present a slanting surface to the material to be crushed. Also, the projections may be curved or hooked, rather than straight, to present a curved or hooked surface to the material to be shredded.

In some cases and for some purposes, it may be desirable to give the operator of the machine the option of using, or not using, the upward projections 21, 22 and 23. In such machines, suitable means may be provided for raising and lowering the projections 21, 22 and 23. Any suitable means may be used so far as the present

invention is concerned. Fig. 4 illustrates one suitable means. In Fig. 4, openings are provided in the floor 13 of the rotor housing 10 through which the projections 21, 22 and 23 project. The projections may be secured, as by welding, to a base block 59. The upper surface of base block 59 is concave and adapted to mate with the convex outer surface of the floor 13 or rotor housing 10. The base block 59 has a bottom which is inclined at each side and adapted to rest upon a pair of opposing wedge blocks 51, 52. Suitable means, such as hydraulic cylinders 55 and 56, may be provided for moving the wedge blocks 51 and 52, in opposing directions laterally, as viewed in Fig. 4. It will be seen that when the hydraulic cylinders 55 and 56 are actuated to withdraw the pistons 53 and 54 the wedge blocks 51 and 52 will be drawn apart, allowing the supporting base block 59 to drop downwardly thereby withdrawing directly downwardly the projections 21, 22 and 23 from their upward operative position. The means illustrated in Fig. 4 for raising and lowering the projections 21, 22 and 23, is merely one of a number of suitable means which may be provided for raising and lowering the projections.

In the preferred embodiment, and as seen in Fig. 2, the individual projections 21, 22 and 23 of each of the three rows are staggered relative to the other projections of the same row, and are not in direct alignment transversely. With this staggered arrangement, the material which is hit by the hammers 14 engages successively, rather than simultaneously, the projections of each row, and this action facilitates the crushing and shredding of the material.

It has been found that the action, on the material, of the rapidly moving hammers and the projections, produces a relatively uniform product size. This desirable product is believed to result from the fact that the projections project up between the hammers. In some installations, it may be desirable to utilize three-prong hammers, or multi-pronged hammers, such as are illustrated by hammers 114 in Fig. 6, rather than the hammers 14 illustrated in Figs. 1-5. The hammers 14 have two prongs in the same vertical plane.

If desired, water can be added to the hammer area to reduce the power demand. The addition of water also tends to keep down the temperature within the machine. Fig. 5 illustrates one way in which water may be applied to the material which is to be shredded and reduced. In Fig. 5, water from a supply 61 runs down the floor of the feed chute 19 and forms a film of water across the entire surface of

the floor. The material which is introduced into the machine at the feed chute 19 slides down on the water film. Water may also be introduced at inlet 62 in the roof of the housing 10. The water coats the surfaces of the rapidly moving hammers 14 and hammer rotor discs 12. The addition of water also decreases the tearing strength of and lubricates the feed material as it passes through the machine. This decreases any braking action which may occur when the material is forced through or past the stationary teeth 21, 22 and 23.

Since the machine does not depend upon a grate system for particle sizing and the use of centrifugal force on other particles to force material through the grate sections, the operator has more flexibility in selecting the type and amount of dust suppression liquid that can be added. Operations using this type of equipment will be able to provide a cleaner area in the immediate vicinity more suitable to people working in or around that particular facility. The size of the end product is affected by, and may be controlled by, the width of the moving hammers, the width of stationary projections, and the extent to which the projections intermesh with the rapidly moving hammers.

In practice, large heavy mass particles which are difficult or impossible to reduce will occasionally get into the machine. Yet such particles, having got into the machine, must be passed through the machine if a shut-down is to be avoided. If the particles cannot be shredded and/or broken, the projections will hold the material and prevent it from passing through. The swinging hammers 14 will lay back out of the way until the operator withdraws the projections. If the projections are withdrawable and are withdrawn, the rapidly moving hammers may strike and impart sufficient energy to the uncrushable material to cause it to be flung into the discharge conduit 30.

Material of the type referred to above, which for one reason or another cannot be reduced in size and must be passed through the machine in its original form, will for convenience be referred to herein as problem particles. Such problem particles will usually be of high density and have a great deal of mass. Thus it will be advantageous if the swinging hammers are of sufficient length that they can lay back adequately to pass over the problem particle and yet have enough weight so that when the projections are withdrawn the hammers will stand out and impart sufficient momentum to the problem particle to propel it to its ultimate destination in the discharge conduit. The fact that a

problem particle is in the machine and refuses to pass through the projections can be sensed in a number of ways. Ordinarily, under such conditions, the motor will draw an exceptionally high current which may be sensed, and the sensing of such high current may be interlocked with and control the mechanism for the withdrawal of projections. Or, the fact that the hammers are being forced to lay back can be sensed by vibration indicators. Or, the operator may control the withdrawal of the projections when he notices the obvious change which occurs in the machine operation when a problem particle is jammed therein.

It is possible to operate the apparatus of the present invention in such a way that the majority or perhaps substantially all of the total mass of material charged to the housing is discharged from the housing during its first pass around the hammer circle. This is made possible in part by the fact that grates or impact surfaces to inhibit the forward movement of the crushed and/or shredded material are omitted from that portion of the apparatus which is upstream of a separating station to be described hereinafter. The energy which is initially imparted to the material, and which is utilized in part for breaking, shearing, bending or shredding purposes, is not totally consumed when those objectives are accomplished, and as a consequence a good portion of the initial energy can be utilized for projecting the trash or other particles forward from the reduction area at a velocity considerably higher than they had when entering the said area, and for facilitating separation of lighter and heavier pieces.

Ignoring for the moment, the effect of air flow, the forwardly projected particles will continue for a time on the path into which they are directed by the impact of the hammers until they drop downwardly through an opening in the machine. The small particles, or less dense particles, will drop downwardly first. The largest and heaviest particles will drop down and be removed last.

Since the apparatus of the present invention is to be used to crush and shred materials of many different varieties, covering a wide range, there would usually be a wide variation in the distance to which particles are projected by the hammers. Such wide variation can be reduced, and separation and conveying of the shredded material can be further facilitated, by the use of controlled air flow.

For instance, in the apparatus of the present invention, the rapidly rotating hammers themselves can be used to create a substantial air flow in the forward direc-

tion, as indicated by the arrows in the discharge conduit 30. Heavier material, such as steel, has a sufficiently large mass-to-surface area relationship that when momentum is imparted to it by the hammers the steel will maintain velocity in the direction in which it is propelled for a relatively long distance. Paper, on the other hand, has a relatively poor mass-to-surface area relationship and soon loses its forward velocity. However, if the paper is moving in a fluid medium, such as air, which is travelling at about the same velocity as the paper, the paper will tend to move with the medium.

Referring specifically now to the apparatus shown in Fig. 1, the less dense materials, such as paper, especially those with relatively large surface areas, may be diverted from the main discharge conduit 30 into a lateral or branch conduit 31 by control of air flow. For example, branch 31 may lead to a receptacle 41 having an open damper 44 so that the air flow created by the rapidly moving hammers 14 flows into the branch 31 and out via damper 44. The less dense particles, such as paper, can then be caused to follow the air flow into the branch 31 and into the receptacle 41.

Material of somewhat greater density than paper will, under the influence of the initial velocity imparted to it by the rapidly rotating hammers, pass by the nearest branch 31 but will be drawn into a second lateral or branch 32 by the flow of air thereinto. The extent to which air from the hammer circle flows into branch 32 is controlled by damper 45.

The denser particles, such as steel, will not be affected by the air flow but will travel up the main discharge conduit 30 under the impact of the rapidly moving hammers until the force of gravity causes sufficient change in their trajectory. These particles will ordinarily travel all of the way up the discharge conduit 30 and either fall into, or be deflected by the surface 34 into, the last and most remote lateral 33.

The discharge of air from the hammer circle into the most remote lateral 33 where it is not needed would only serve to diminish the amount of air flow available for useful purposes in the nearer branches 31 and 32. Thus, means can be provided for preventing such discharge. For instance, as shown in Fig. 1, hydraulic cylinder 71 controls the position of an upper door 72. The steel and other dense material particles which the hammers 14 throw up the discharge conduit into lateral 33 accumulate on upper door 72. The upper door 72 is then slidingly opened by hydraulic cylinder 71 and the material

drops down on to a lower door 74 which is then in closed position. The upper door 72 is then slidingly closed, and thereafter the lower door 74 is slidingly opened by hydraulic cylinder 73 to allow the material to drop down into receptacle 43. It will be seen that by the means shown, the receptacle 43 may be removed and emptied without opening remote lateral 33 to the atmosphere, thereby avoiding diverting air flow from branches 31 and 32 even when the receptacle 43 is removed to empty its contents.

Fig. 8 is a fragmentary illustration of a crusher/shredder and classifying apparatus generally similar to that illustrated in Fig. 1 but differs to the extent that the least dense particles are carried upwardly into branch 31, the next denser particles are carried laterally into branch 32, and the most dense particles are carried up main discharge conduit 30 and then downwardly into the outermost branch 33.

Figs. 9, 10, 11 and 12 illustrate various positions which the input chute 19 and discharge conduit 30 may take relative to the rotor housing 10.

Fig. 13 illustrates an alternative means for adjusting the positions of projections 21, 22 and 23, inwardly and outwardly relative to the floor 13 of the rotor housing 10. In Fig. 13 an arcuate plate 71 corresponding in curvature to the arcuate floor 13, is mounted pivotally just below the floor 13 by pivot pin 72, on a bracket 73, and the projections 21, 22, 23 are secured, as by welding, to the upper surface of the plate 71. A bolt 76 is threaded into the forward end of plate 71. Bolt 76 is provided with a pair of nuts 74 and 75, each having a spherical seat facing the spherical seat of the other nut. These seats rest on opposite edges of a slot 78 in a support bracket 79. This prevents plate 71 from dropping down. To adjust the projections 21, 22 and 23, for example downwardly, relative to the floor 13, the upper nut 74 is loosened to the desired extent, by turning nut 74 upward on the bolt 76. This allows the plate 71 to drop down and as it does so bolt 76 swings to the right, as viewed in Fig. 13. The lower nut 75, which has moved downwardly relative to slot 78 is now tightened upwardly against the edges of slot 78. To adjust the projections 21, 22 and 23 upwardly, the procedure is reversed, i.e., the lower nut 75 is loosened by turning nut 75 downward on bolt 76 to the desired extent and bolt 76 is pushed to the left to raise plate 71 to the desired extent. The upper nut 74 is then tightened downwardly on bolt 76.

Fig. 14 illustrates one way in which three crusher/shredder hammer rotor mechanisms 10, 110 and 210 may be con-

ected in tandem. It will be seen that some of the material which has been partially crushed and shredded by the rotating hammers of unit 10 will be received through input chute 119 into the hammer circle of 110 where it will be further crushed and shredded. Similarly, some of the material discharged from the hammer circle of unit 110 will be received through input chute 219 into the hammer circle of the third unit 210 for further crushing and shredding.

Fig. 15 illustrates an arrangement in which all of the material which is discharged from the hammer circle of the first unit 10 is received through input chute 119 into the hammer circle of the second unit 110 for further crushing and shredding.

Fig. 16 illustrates a crusher having a feed conveyor 136, housing 120, hammers 123 and a discharge conduit 124. The latter is provided with a return conduit 124R for returning the heavier coarser particles to the hammer circle. The heavier particles which pass by the discharge nozzle 122, hit the wall of the conduit as at 124W and are diverted upwardly into the return conduit 124R which returns the particles back into the hammer circle.

As shown in Figs. 17 and 18, the air flow may follow any desired flow path and need not necessarily be generated by the rotatable impacting means. Figure 17 shows a crusher/shredder having a housing 216 which is supported on elevated base 209 and has input chute 229 and output chute 230. Two branch conduits 231 and 233 communicate between output chute 230 and light and heavy particle receptacles 241 and 242, respectively. In output chute 230, downstream of branch conduit 231 is a damper 245 or other means for admitting air to the chute. A centrifugal blower 238 has its suction port 237 in communication with light particle receptacle 241. During operation of this unit, the rotor in housing 216 draws air from the atmosphere through inlet 229. The air follows a common flow path through the housing and is discharged into outlet chute 230 with the stream of light and heavy particles propelled up the chute by the rotor. When blower 238 is of sufficient capacity, it will not only draw air from the stream of particles moving downstream from housing 216, but will also induce a flow of air upstream in chute 230 from damper 245 to branch conduit 231. There, the respective flows of air will combine, entering conduit 231 and drawing light particles off from the solids stream into receptacle 241. Heavier particles in the stream will continue up chute 230 until they strike an energy absorbing and direc-

tion changing means 234 before descending into branch conduit 233 and receptacle 242.

Like numbered parts in Figs. 17 and 18 are the same and serve similar purposes. However, in the Fig. 18 embodiment, the input chute 229 includes a star feeder 239 or equivalent device so that the inlet side of housing 216 is effectively closed off from the atmosphere. In this embodiment, there is a damper 246 located in the output chute 230, intermediate housing 216 and branch conduit 231. During operation of this unit, the closed inlet inhibits generation of air flow by the hammer rotor. The blower 238 draws air in through damper 246 so that it joins the stream of light and heavy particles in the output chute. The air and light pieces are drawn off and the heavy particles continue in flight as in the preceding embodiment.

The Fig. 18 embodiment can also be operated in a form wherein the damper 246 is supplemented or replaced by a damper 245 located in the position shown in Fig. 17. Either or both of these dampers may be open during operation of the blower, resulting in air passing upstream, downstream or in both directions in output chute 230, relative to its intersection with branch conduit 231. Similar air flow patterns may be provided by connecting the pressure side of a blower or blowers to chute 230 where dampers 245 and/or 246 are located. In such case, a damper or other air flow control means may be connected to receptacle 241 at the same place as suction port 237, and blower 238 may be eliminated.

WHAT WE CLAIM IS:—

1. A material reduction apparatus comprising a rotor housing, a material inlet into the housing, rotatable impacting means mounted in the housing for subjecting the material to blows for reducing and propelling away from the impacting means a stream of solid material including lighter and heavier pieces, a reduced material outlet extending from the impacting means, which outlet comprises a first path having at least one path diverging therefrom, and means for providing a flow of air at least in the outlet path to direct the lighter material along said at least one diverging path thereby diverting at least a portion of the lighter pieces from the first path.

2. Apparatus as claimed in claim 1 including stator means positioned adjacent the rotatable impacting means.

3. Apparatus as claimed in Claim 2 in which the impacting means includes a plurality of hammers mounted for rotation in a hammer circle, the hammers being spaced apart parallel to their axis of rota-

tion and the stator means include projections which extend inwardly from the housing into the hammer circle between the paths of rotation of the axially spaced hammers.

4. Apparatus as claimed in Claim 3 in which the projections are staggered in a direction parallel to the axis of rotation of the hammers.

10 5. Apparatus as claimed in Claim 3 or Claim 4 in which adjustable means are provided for withdrawing the projections partially or completely from the hammer circle.

15 6. Apparatus as claimed in any preceding claim in which means are provided in the apparatus for wetting the material.

7. Apparatus as claimed in any preceding claim in which a receptacle for reduced material is connected to said at least one diverging path and includes adjustable air flow control means.

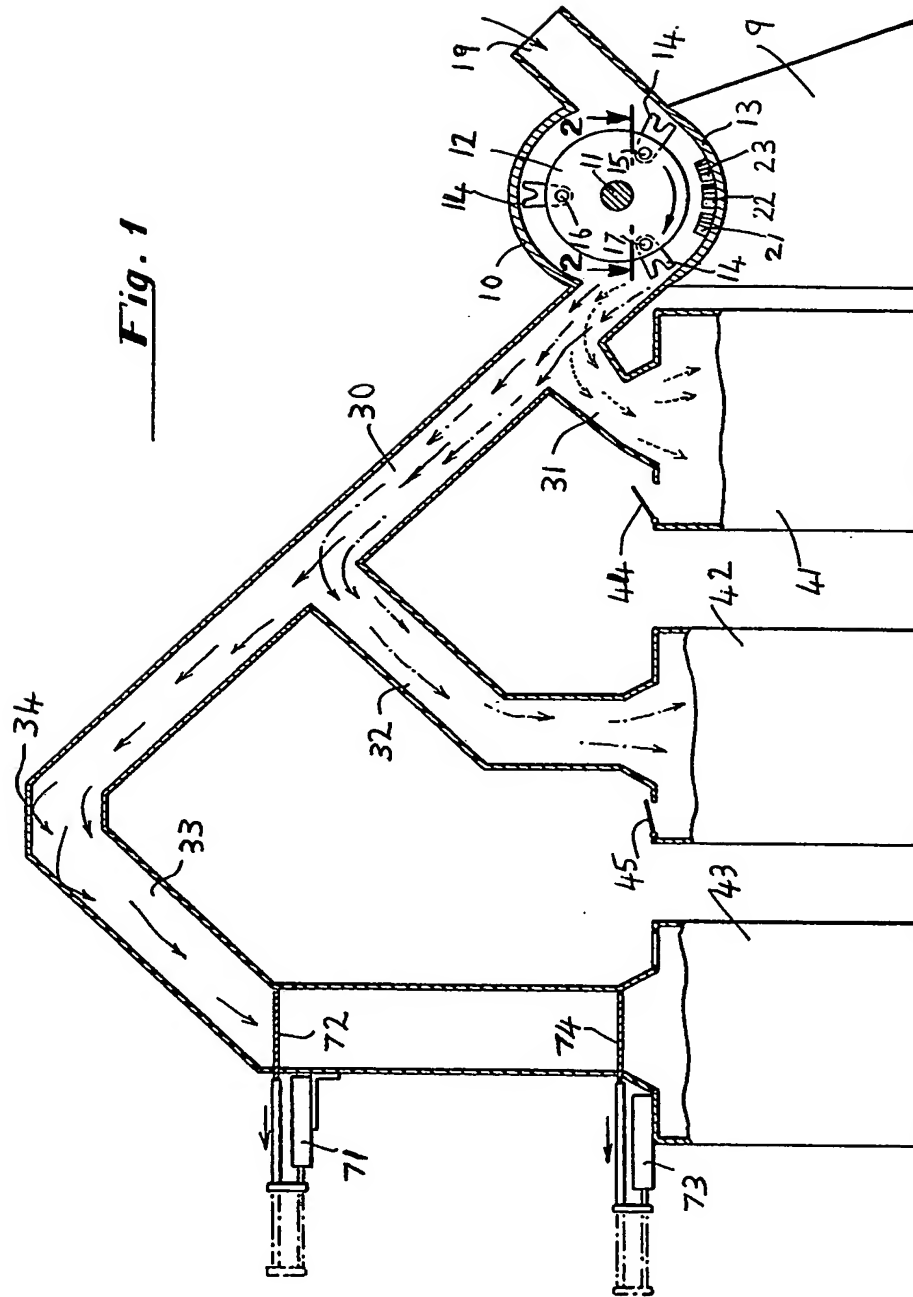
20 8. Apparatus as claimed in any preceding claim in which the rotatable impacting means includes a plurality of hammers mounted for rotation in a ham-

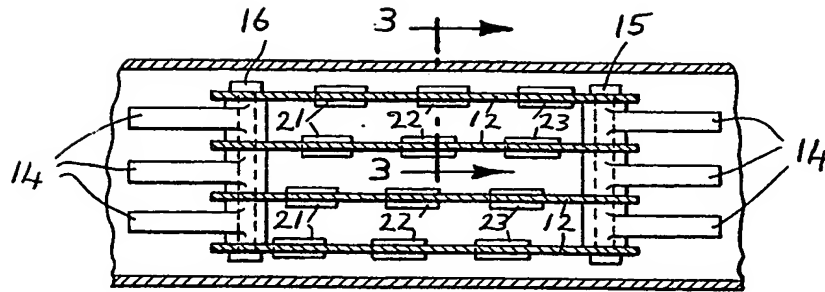
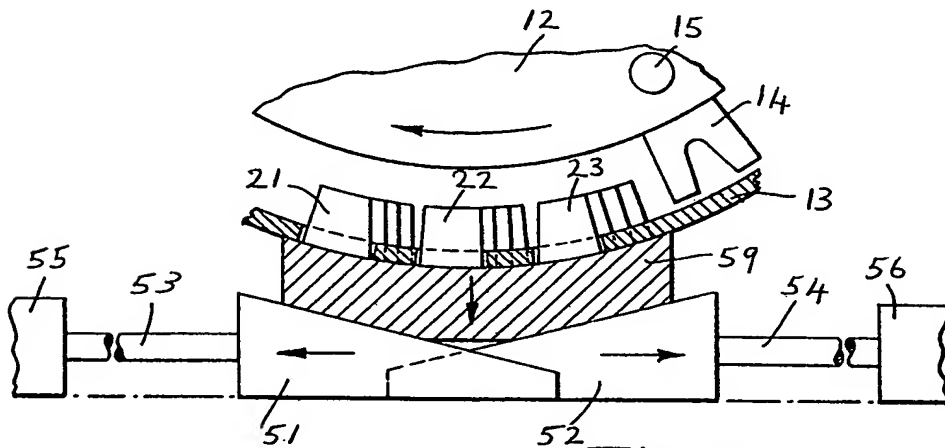
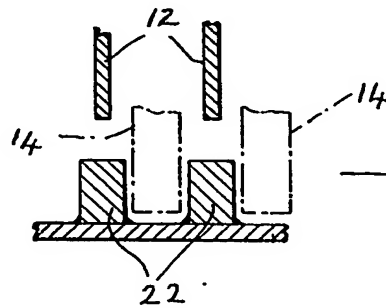
mer circle, the hammers each being provided with plural tip portions spaced apart parallel to their axis of rotation and projections forming the stator means extend 30 into the hammer circle between the paths of rotation of the hammer tip portions.

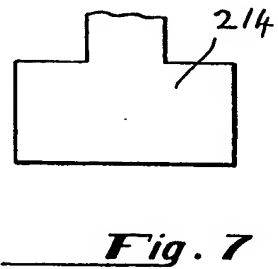
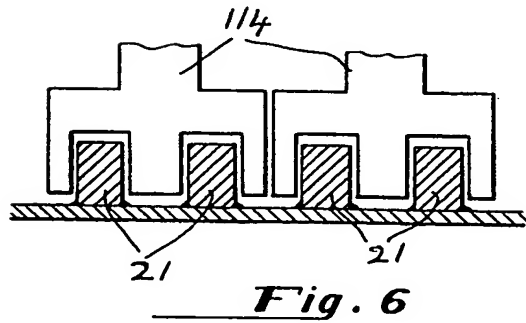
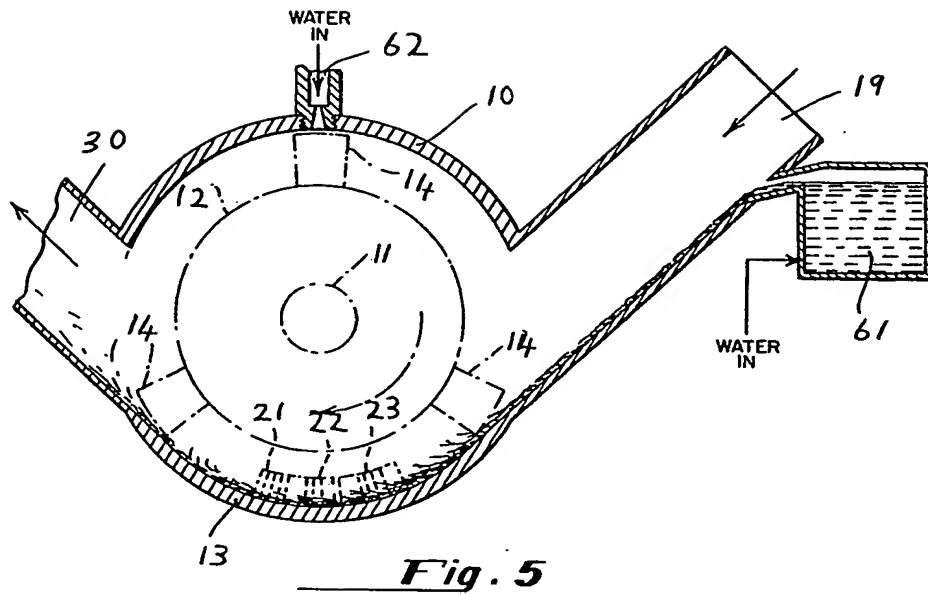
9. A plurality of apparatus as claimed in any preceding claim arranged so that an outlet of one apparatus communicates 35 with an inlet of another apparatus.

10. A material reduction apparatus substantially as herein described with reference to Figures 1 to 3, to Figures 1 to 3 as modified by Figure 4, Figure 5, Figure 40 6 or Figure 7 to Figure 8, to Figure 9, to Figure 10 to Figure 11, to Figure 12 to Figure 13 to Figure 14, to Figure 15, to Figure 16, to Figure 17 or to Figure 18 of the accompanying drawings. 45

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*Fig. 2**Fig. 4**Fig. 3*



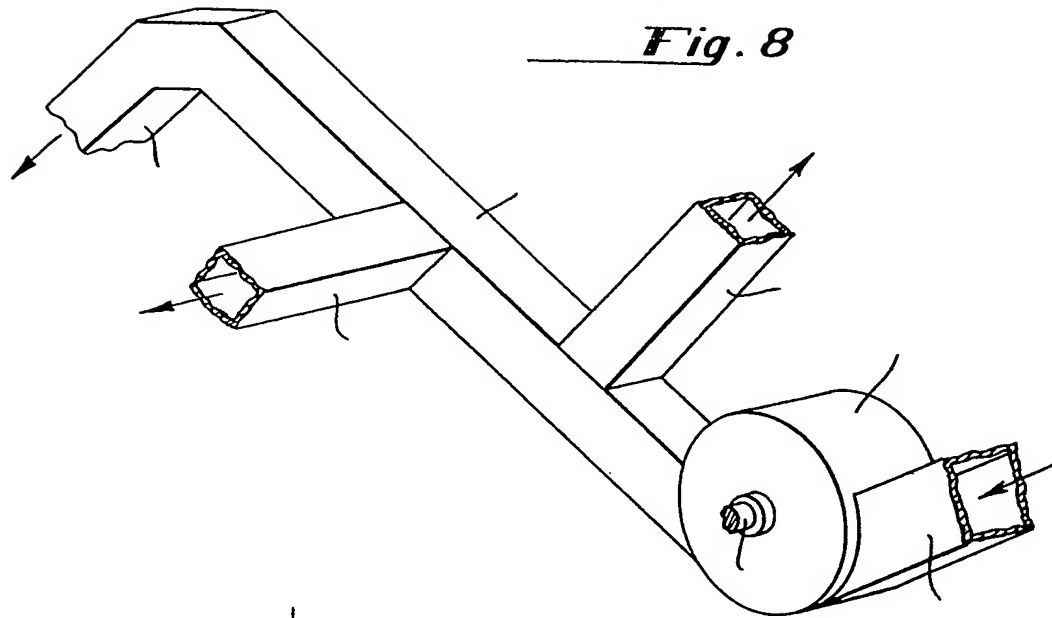


Fig. 8

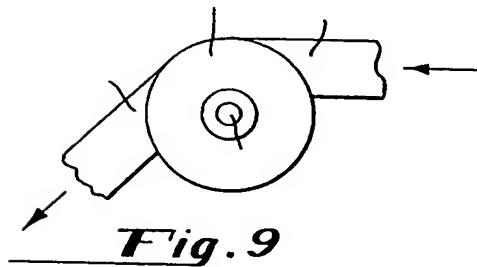


Fig. 9

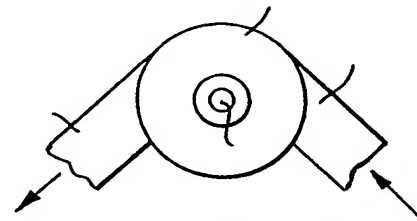


Fig. 11

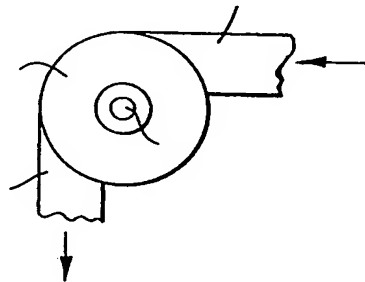


Fig. 10

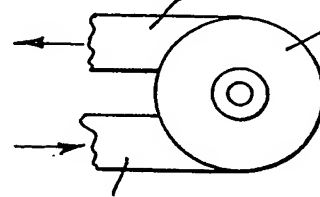
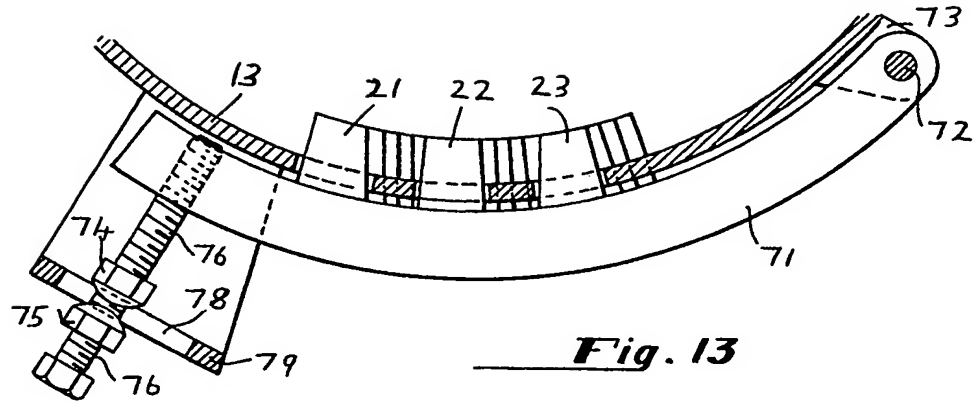
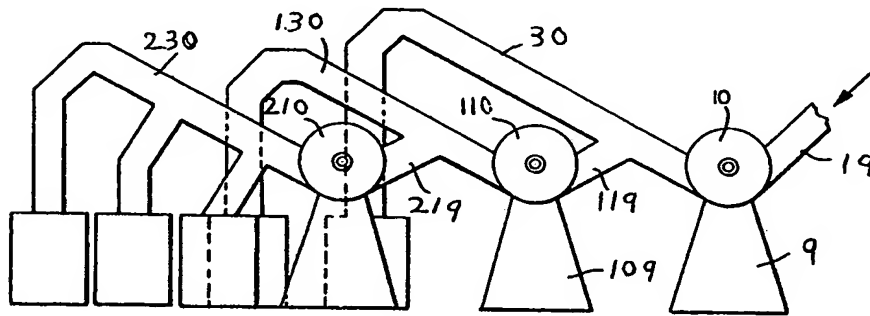
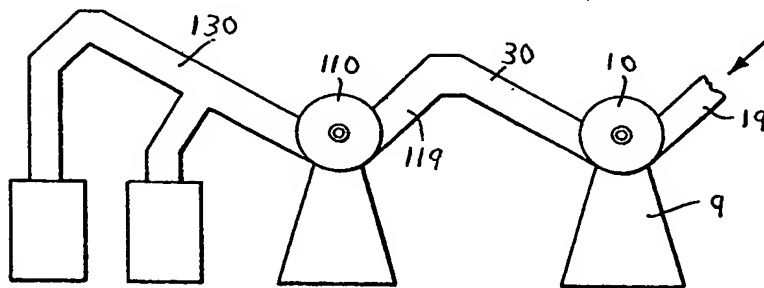
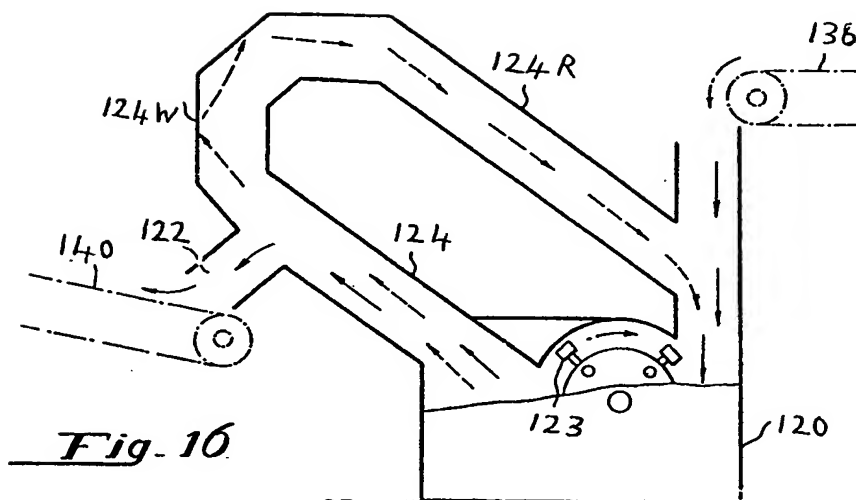
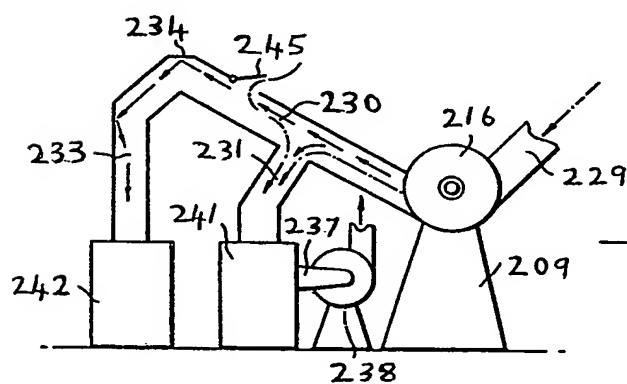
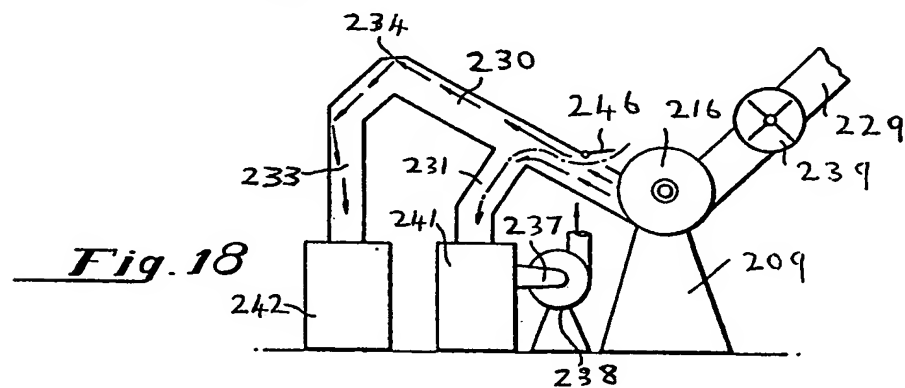


Fig. 12

**Fig. 13****Fig. 14****Fig. 15**

**Fig. 10****Fig. 17****Fig. 18**